Engineering Design and Fabrication of an Ampere-Class Superconducting Photocathode Electron Gun *

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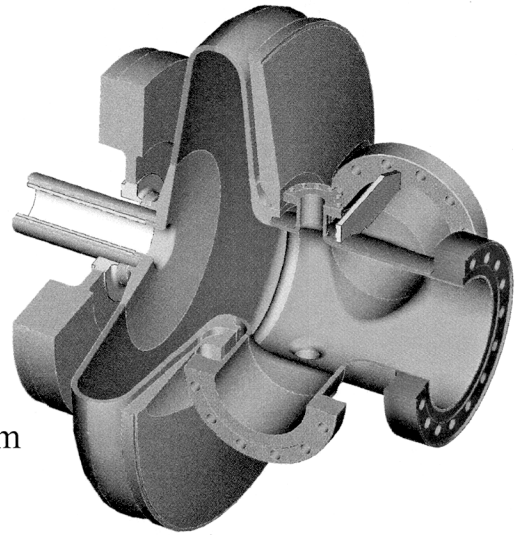
Abstract

Over the past three years, Advanced Energy Systems and Brookhaven National Laboratory (BNL) have been collaborating on the design of an Ampere-class superconducting photocathode electron gun. BNL performed the physics design of the overall system and RF cavity under prior programs. Advanced Energy Systems (AES) is currently responsible for the engineering design and fabrication of the electron gun under contract to BNL. We will report on the engineering design and fabrication status of the superconducting photocathode electron gun. The overall configuration of the cryomodule will be reviewed. The layout of the hermitic string, space frame, shielding package, and cold mass will be discussed. The engineering design of the gun cavity and removable cathode will be presented in detail and areas of technical risk will be highlighted. Finally, the fabrication sequence and fabrication status of the gun cavity will be discussed.

SRF Injector

- 0.5 Amp Beam
- 1 MW Beam Power
- Q_{EXT} 37,000
- E_{PEAK} 35.712 MV/m
- H_{PEAK} 58736.4 A/m
- $E_{CATHODE}$ 20 MV/m
- E_{ACC} (to iris) ~22 MV/m



Objectives & Comments

- Design & fabricate a 0.5-cell Superconducting RF gun & choke joint fed by two 0.5 MW RF power couplers
- Test device on the BNL ERL Ring
- Collaboration with JLAB, BNL, FZR & other FEL stakeholders

Target Parameters

Frequency	703.75	MHz
Energy	2	MeV
Current	500	mA with PRF of 352 MHz
Bunch Charge	1.33	nC
Transverse Emittance*	5.5	mm-mrad rms normalized
Longitudinal Emittance*	42	keV-psec rms
Energy Spread*	3.1	%
Bunch Length*	7.2	psec rms

* No emittance compensation

Schedule

- Choke configuration downselected – 6/04
- Niobium ordered – 12/04
- Preliminary design review – 1/05
- Final design review 12/05
- Testing of SC choke joint underway
- Transition to BNL/DOE Contract 1/07
- NSWC Task Closed
- Progress Limited by Funding Delays
- Delivery to BNL by ~ 3/09
- Initial testing at BNL by ~ 12/09

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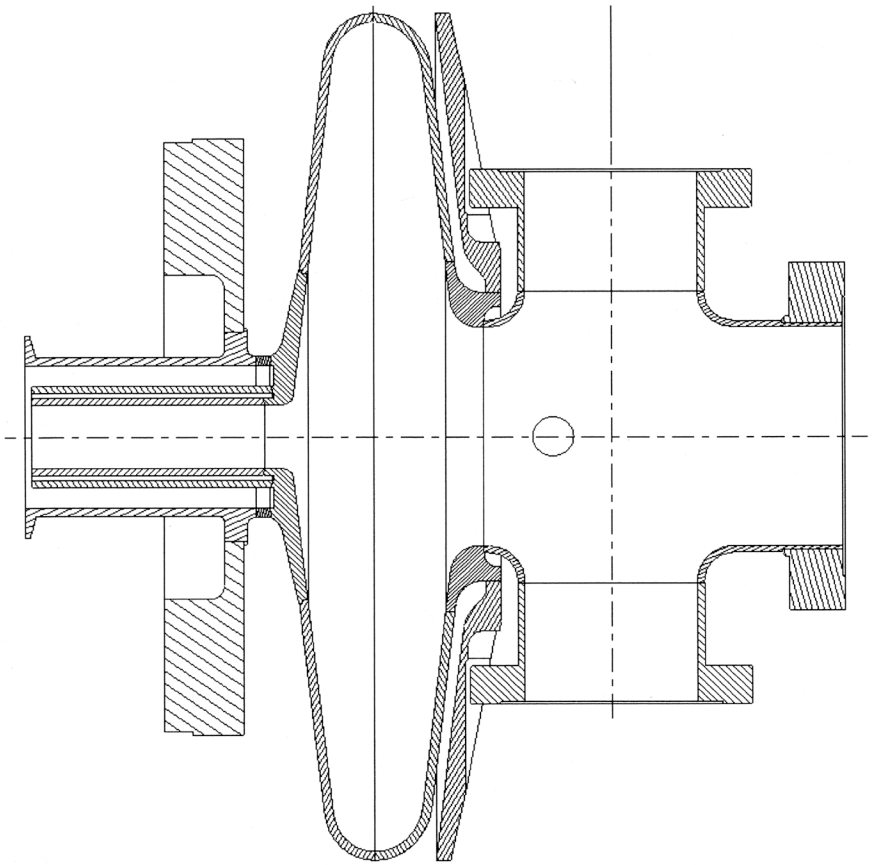
Advanced Energy Systems, Inc.

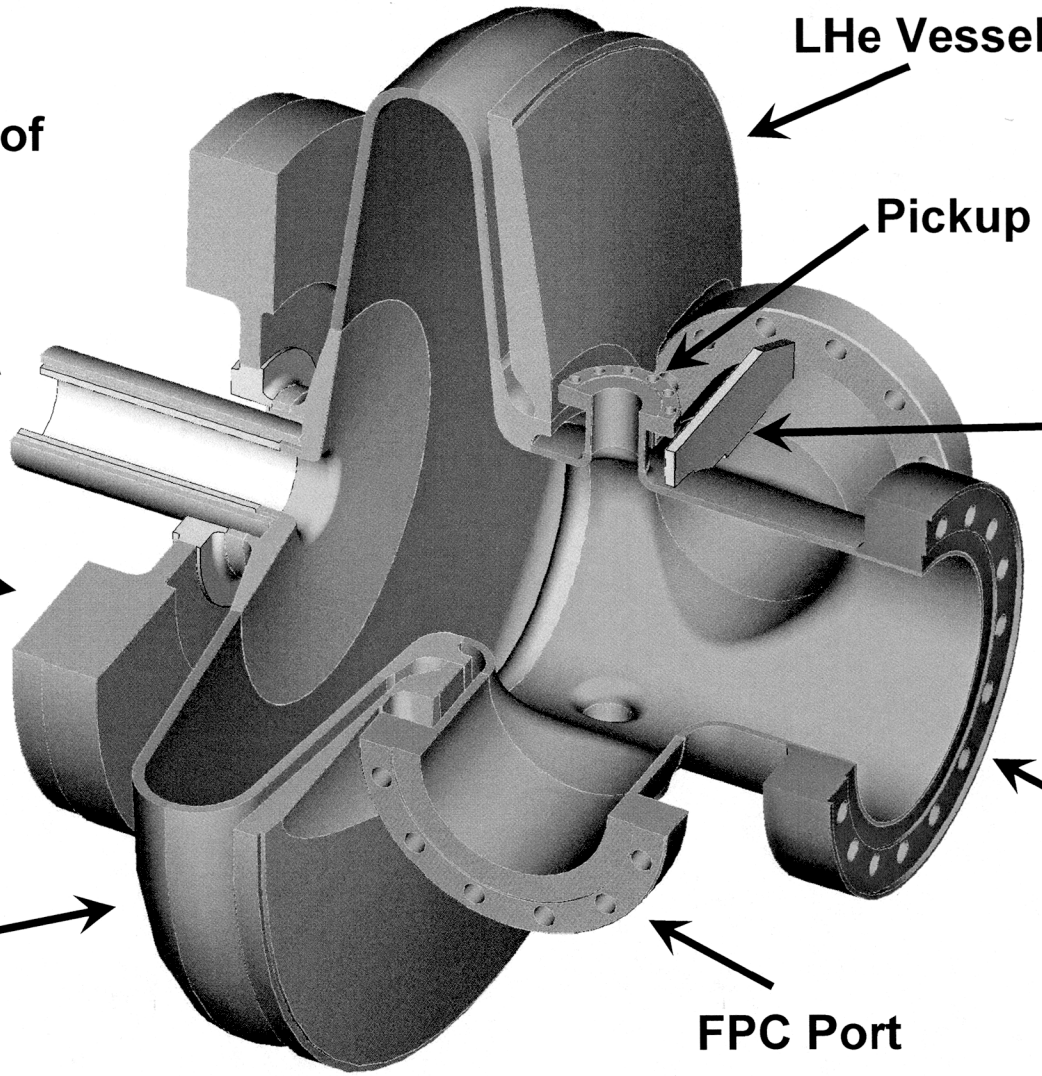
Cavity Configuration



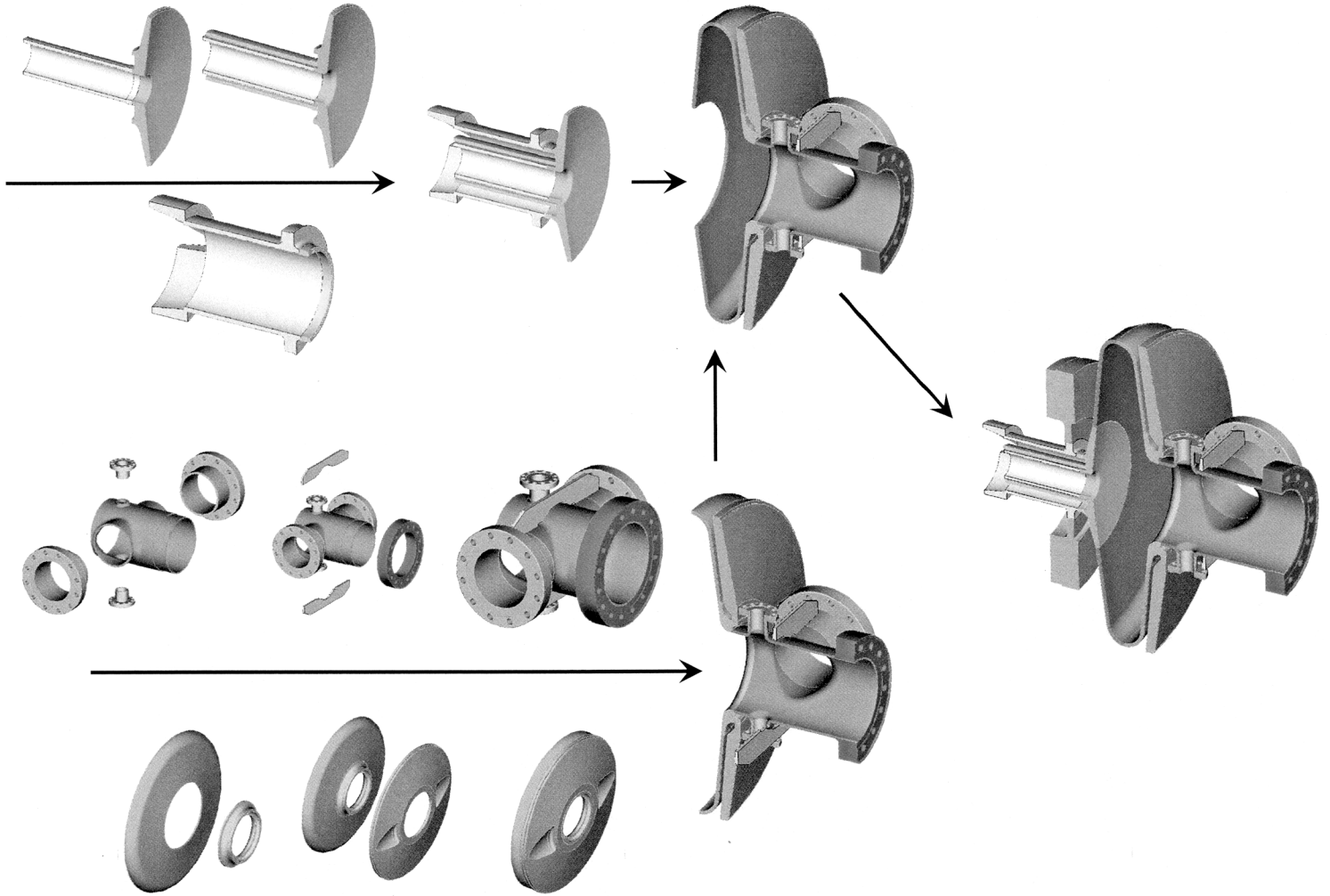
- Formed half cells with machined irises
- 10 cm Beam Pipe diameter
- Machined parts for helium vessel "dish" components
- Close FPC Coupling
- Good field probe pickup-to-cavity coupling
- Geometry optimized to minimize stress from evacuation and over pressure condition

	SF (SC w Cu Cathode)	
Frequency	703.632	MHz
E0	8.500	MV/m
TTF	0.888	
U	8.366	Joules
Pcav	156.9	W
Q0	2.36E+08	
Pbeam	1.0E+06	W
QL	36973.3	
Qe	36979.1	
Beta	6374.3	
L (Z)	0.25	m
Epeak	35.712	MV/m
Hpeak	58736.4	A/m

Cavity Design



Cavity Weld Sequence



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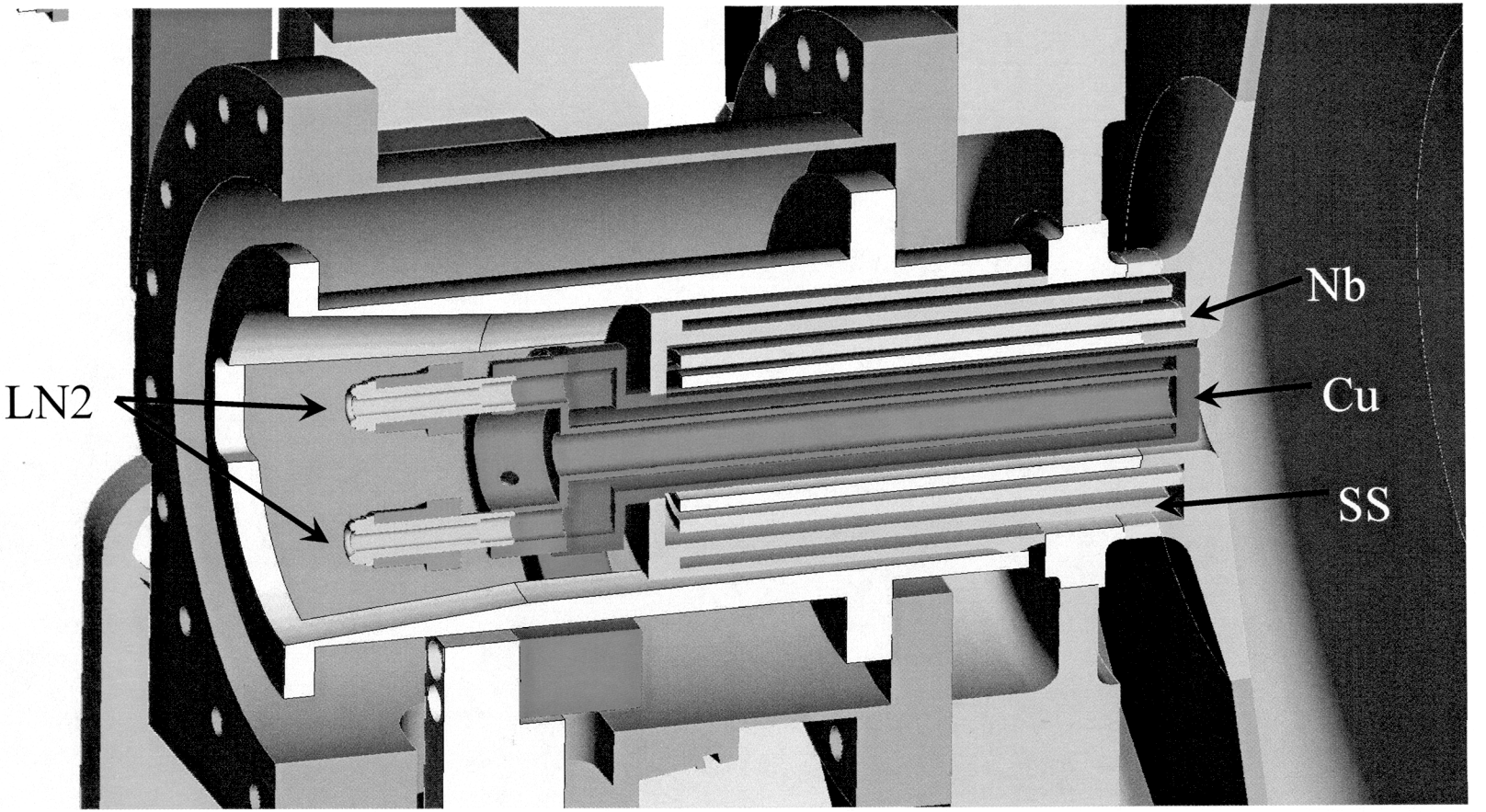
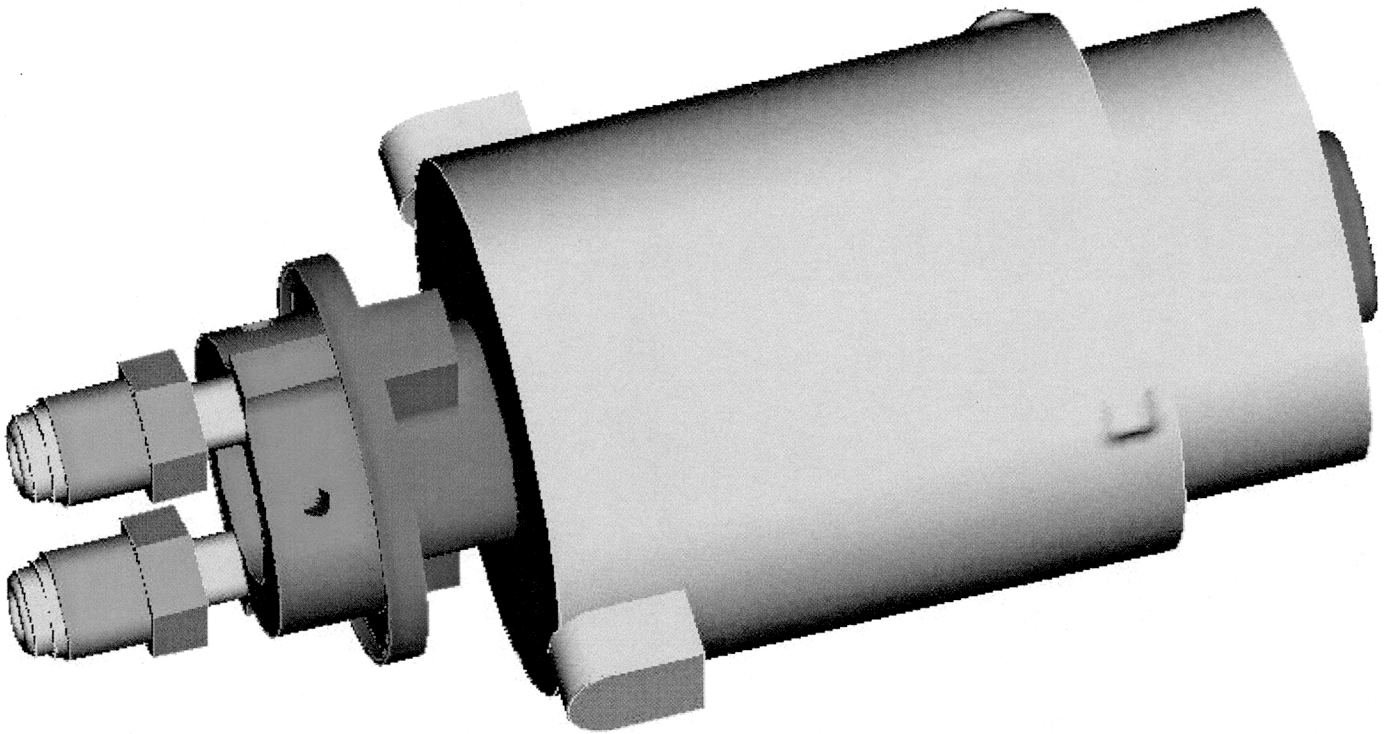
Cathode Choke Installation Details

Removable double quarter wave choke cathode installed in cavity. Cavity side choke components are SC Nb. Actual choke surfaces will have a grooved multipacting suppression surface treatment

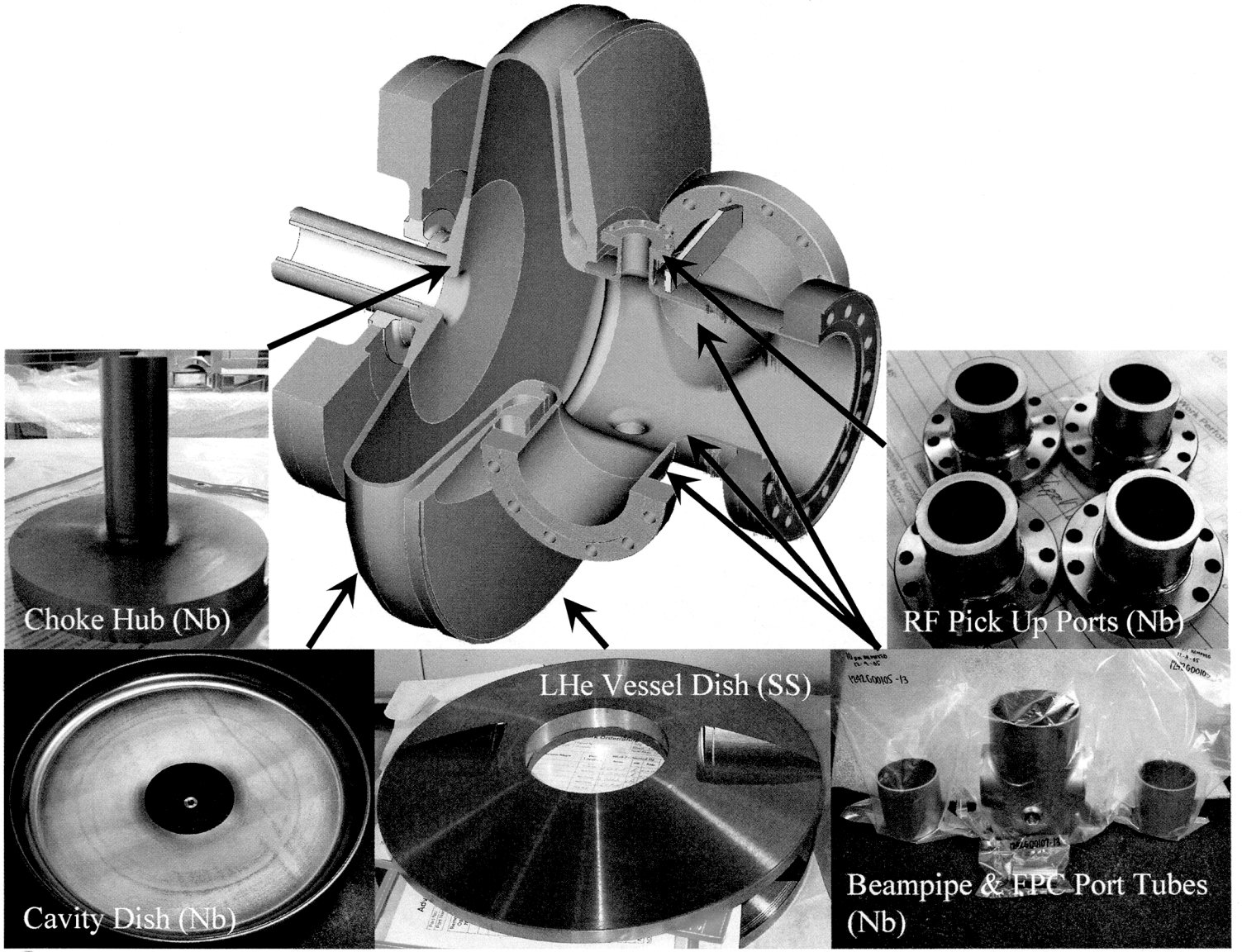


Removable Cathode

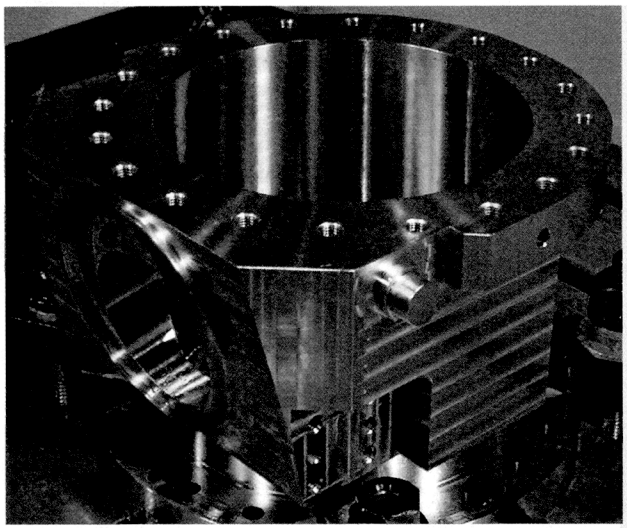
Removable double quarter wave choke cathode.
NC Copper and SS cooled with LN2.

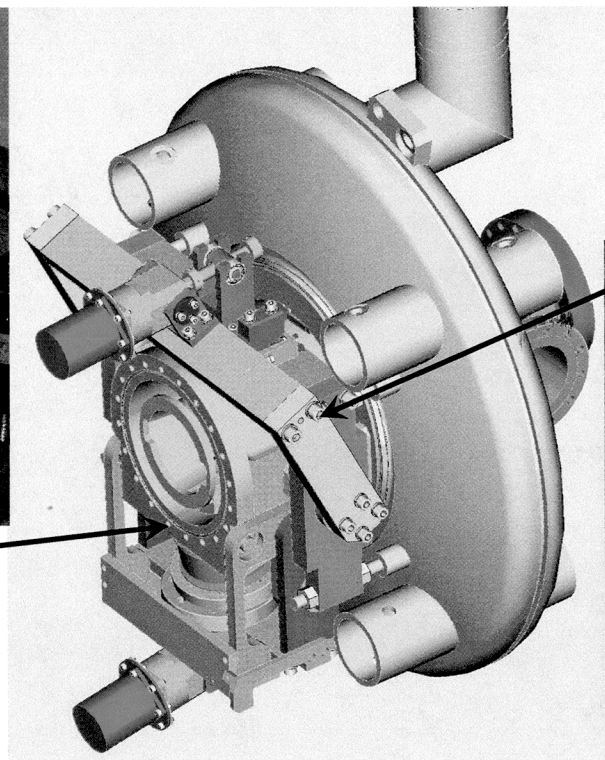


Cavity Fabrication Status



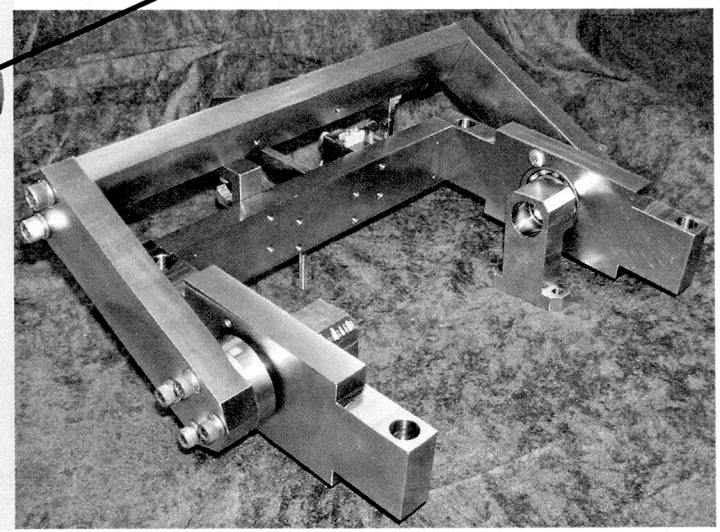
Clamp and Tuner Fabrication Status



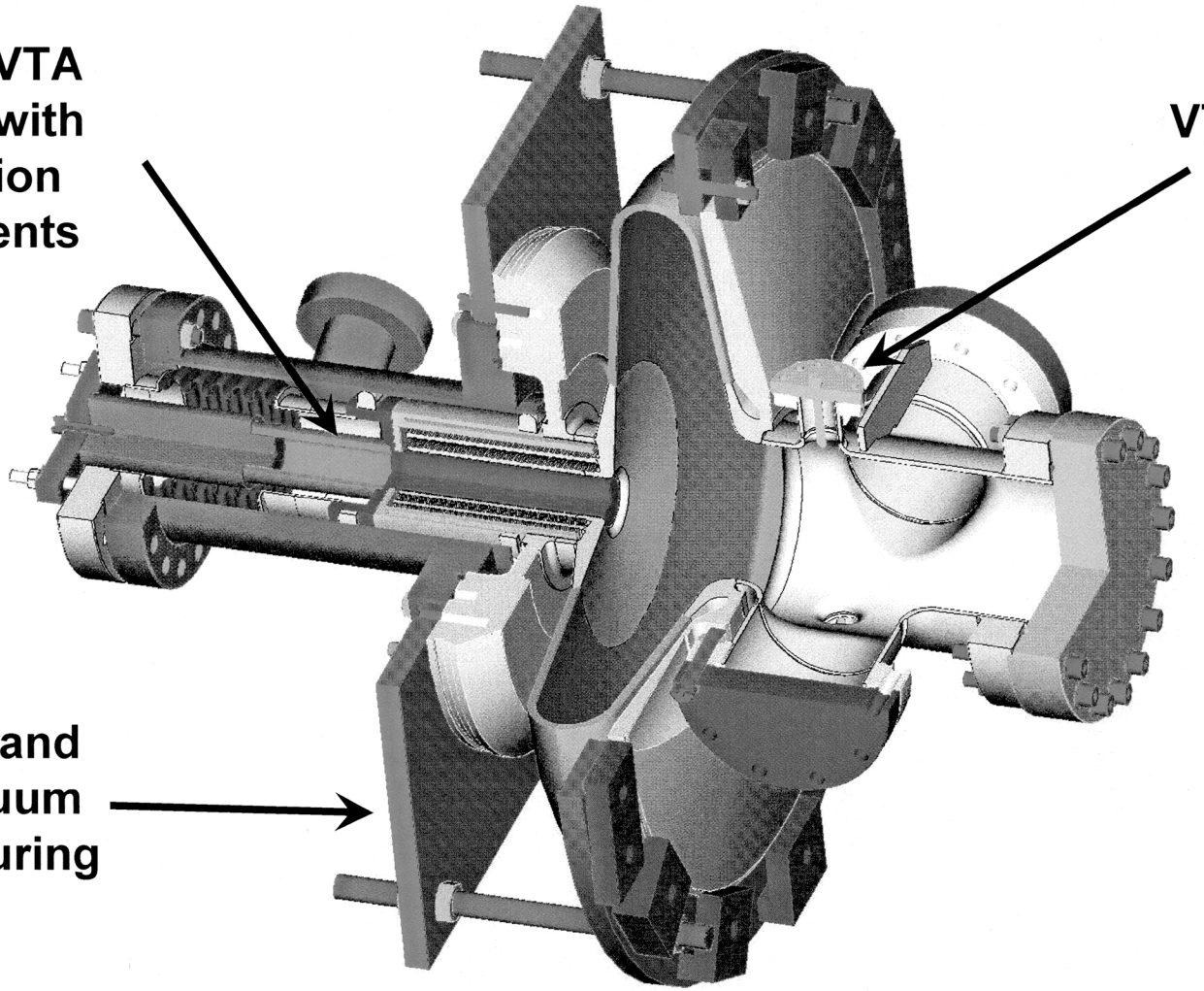


Clamp and Tuner Hub

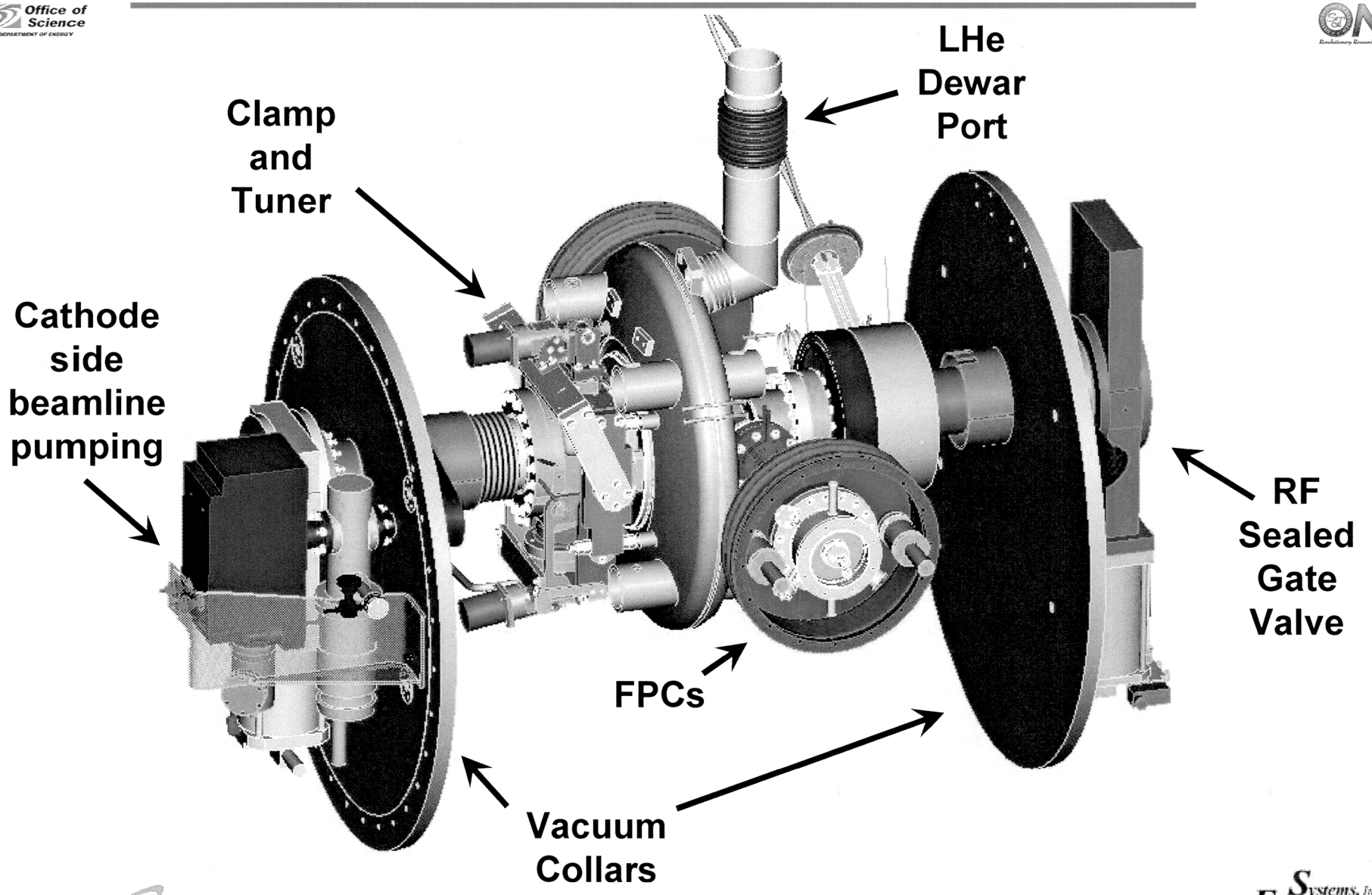
Tuner Arms



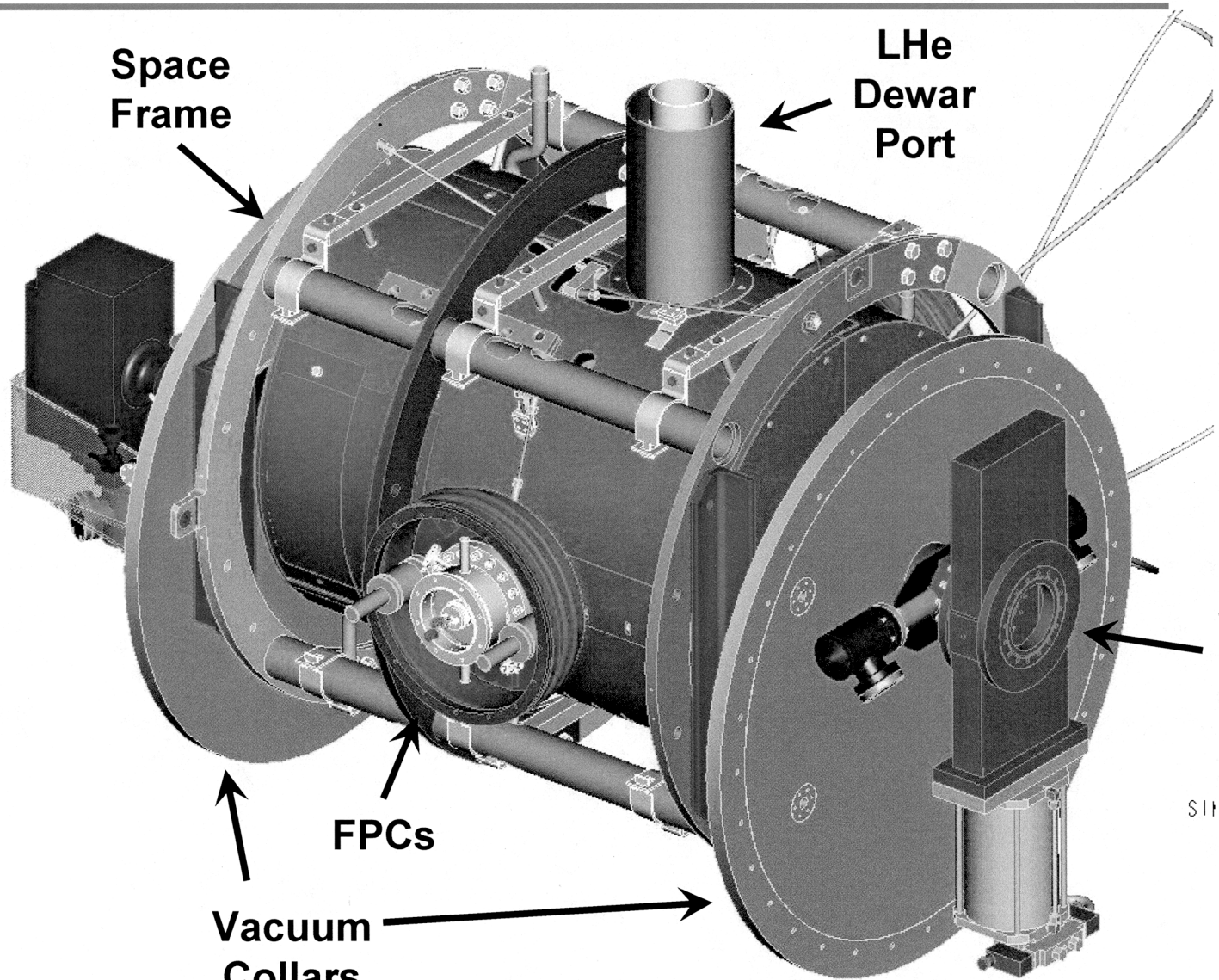
VTA Test Configuration



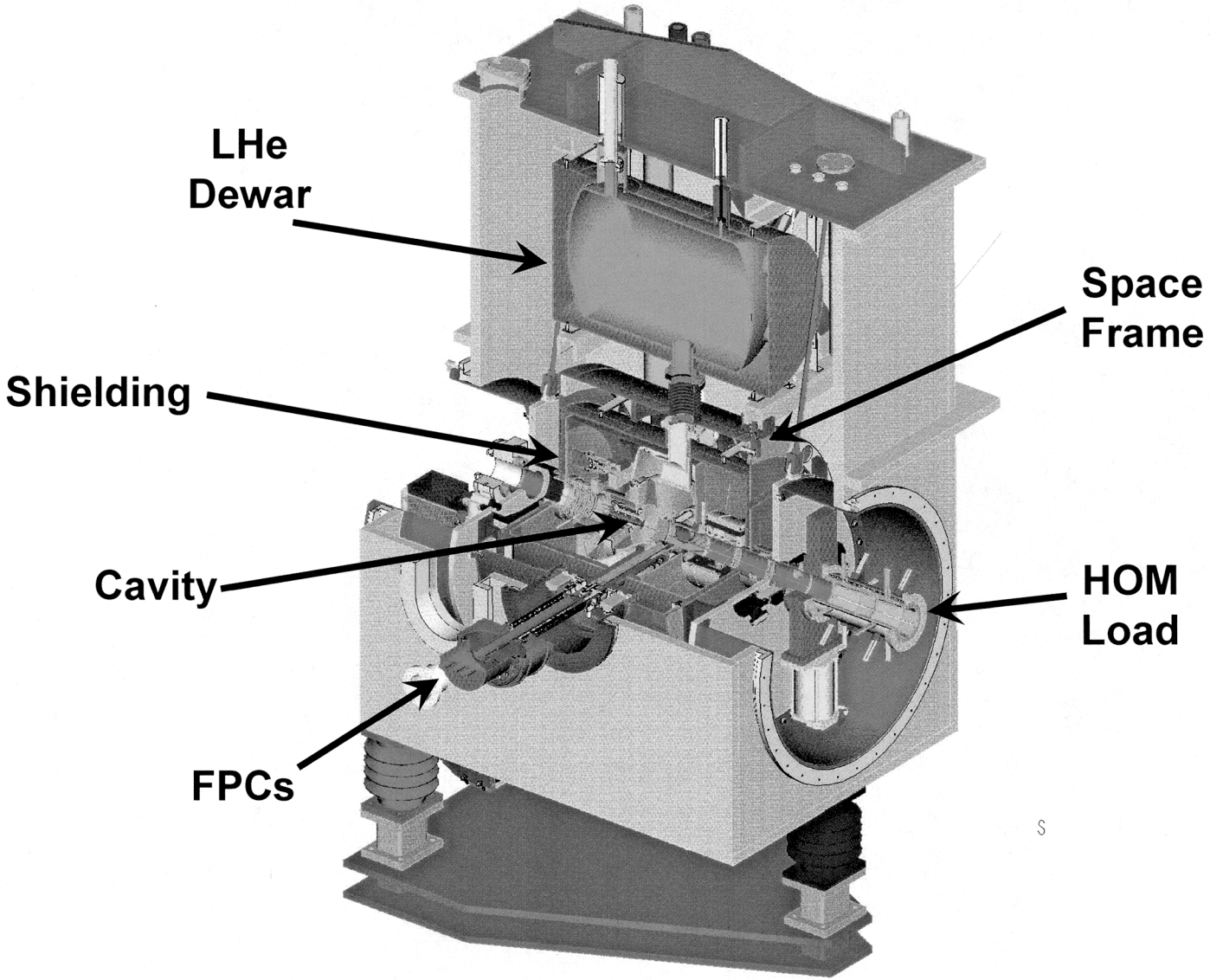
Hermetic String Assembly



String with Space Frame and Shields



SRF Gun Cryomodule



Current Status

- Detailed fabrication drawings are complete.
- Integration and assembly drawings are in check.
- Integration details and assembly alignment plans worked out with BNL where this work will take place.
- Fabrication of cavity parts underway.
- Procurement and many fabrication tasks pertaining to complete cryomodule on hold based on funding.
- Currently focusing on tasks required to get to cavity VTA test and FPC conditioning.